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# **EUROPEAN PATENT APPLICATION**

②① Application number: 83301496.2

⑤① Int. Cl.<sup>3</sup>: **B 26 F 3/00**

②② Date of filing: 17.03.83

④③ Date of publication of application: 26.09.84  
Bulletin 84/39

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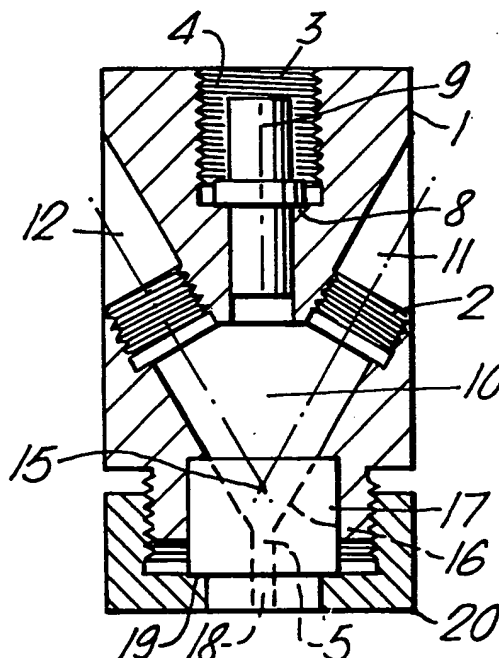
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⑧④ Designated Contracting States: **AT BE CH DE FR GB IT**  
**LI LU NL SE**

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⑤④ **High pressure liquid cutting apparatus.**

⑤⑦ A high pressure liquid cutting apparatus comprises a generally cylindrical body (2) in which a frusto-conical mixing chamber (10) is defined. A nozzle 9 of internal diameter 0.5–4 mm directs water at very high pressure into the mixing chamber (10) causing abrasive material to be sucked into the mixing chamber via inlets (11 and 12). The abrasive material is entrained by the jet of water and the combined jet exits via an outlet passageway 18 defined in an abrasive resistant insert 17. The axes of the inlets are offset from the axis of the mixing chamber.



**EP 0 119 338 A1**

DESCRIPTION

TITLE: HIGH PRESSURE LIQUID CUTTING APPARATUS

5 The present invention relates to a high pressure liquid cutting apparatus and more particularly to an improved cutting head for such apparatus.

10 It is known to use a high pressure jet of water, sometimes with a stream of abrasive material entrained by the jet, to cut a wide variety of materials including constructional materials such as brick, rock, slate and the like. The water is supplied from a very high pressure source typically providing a pressure head of 10,000 psi (666 bar).

15 Some apparatuses, where an abrasive stream is used with the water jet, include a mixing head where the jet issues from a nozzle and in so doing entrains the abrasive to carry it along with it.

20 According to the present invention there is provided a high pressure liquid cutting head comprising a body having a through-passage having at its upstream end an inlet for liquid from a high pressure source, an outlet at its downstream end, a mixing zone intermediate the inlet and outlet ends, a nozzle arrangement for directing a jet of the liquid from the inlet through the mixing zone to the outlet and at least one inlet directed towards the outlet  
25 for introducing into the mixing zone abrasive material to be entrained by the jet of liquid, at least the downstream end of the mixing zone having a lateral wall which converges progressively towards the outlet. Suitably the liquid which is used is water and the abrasive material may  
30 be, for example, wet or dry river sand. As the jet of water issues from the nozzle arrangement into the chamber it produces a reduced pressure in the chamber which causes the abrasive material to be sucked in.

There may be a number of abrasive inlets, preferably symmetrically disposed about the axis of the

through passage.

5            Preferably the arrangement is such that the zone in which the abrasive is entrained in the jet of water is at the downstream end of the mixing chamber; this is intended to reduce the wear on the chamber wall.

10           Preferably the converging lateral wall at the downstream end of the mixing zone is frusto-conical and preferably the whole, or at least the downstream part, of this frusto-conical portion of the wall is defined by an annular insert of abrasion-resistant material e.g. tungsten carbide.

15           The nozzle arrangement is preferably arranged so that the jet issues into the mixing chamber at an optimum distance from the outlet from the point of view of abrasive entrainment and the stand-off from the material which is to be cut.

20           The inlet or inlets for the abrasive material may be parallel with the axis of the through-passage or, more conveniently from a constructional viewpoint, they may be inclined at an angle with respect to it. Where their axes are inclined, preferably they are inclined at the same angle as the angle of the converging lateral wall of the mixing zone.

25           The inlet or inlets may have their axes contained in a common plane with the longitudinal axis of the mixing chamber. Alternatively the inlet or inlets may be located in a plane or planes offset from the axis of the mixing chamber so as to impart a tangential component to the motion of the abrasive material. In either case,  
30           preferably the axis of the, or each, inlet intersects the mixing chamber wall at the downstream end of the converging part defined by the abrasion-resistant insert.

            The invention will be further described with reference to the accompanying drawings in which:-

            Figure 1 is a longitudinal sectional view of one embodiment of cutting head according to the present

invention;

Figure 2 shows in more detail the outlet nozzle insert of Figure 1;

5 Figure 3 shows very schematically and not to scale one form of cutting apparatus incorporating the cutting head of Figure 1;

Figure 4 is a longitudinal sectional view of a second embodiment of the present invention; and

10 Figure 5 is a diagrammatic view illustrating the orientation of the sand inlets of one version of the embodiment of Figure 4 as viewed end-on.

The cutting head 1 shown in Figure 1 comprises a generally cylindrical body 2 of stainless steel having a through-passage 3 extending along the axis of the body from an inlet end 4 to an outlet end 5. The inlet end 4 is threaded to receive a coupling 6 (Figure 3) which is used to connect the cutting head 1 to a pump 7 delivering water at a pressure of about 10,000 psi.

20 At the downstream end of the inlet 4, the through-passage has a stepped reduction in diameter at 8 which provides a seat for a standard nozzle insert 9 which push-fits or screw-fits into position and may be replaced when worn out or when another size of jet is required.

25 The nozzle 9 has at its downstream end a discharge aperture from which, in use, a high velocity jet of water issues and is directed at the outlet 5 of the cutting head. As it issues from the insert 9, it passes through a mixing zone 10 in which it creates a reduced pressure. The part of the mixing zone 10 defined by the body 2 is of circular cross-section and may be generally cylindrical in the interests of ease of manufacture, or more preferably from the theoretical viewpoint, of frusto-conical shape, converging towards its downstream end. The downstream end of the mixing zone 10 is defined by the frusto-conical inner wall 16 of an annular insert 17 of suitable abrasion resistant material such as tungsten

carbide. The wall 16 forms a continuation of the part of the wall of the mixing chamber defined in the body 2. At its reduced diameter end the frusto-conical wall 16 merges with a coaxial cylindrical outlet passage 18. This outlet passage is relatively narrow in comparison with the diameter of the water jet from nozzle 9 so that the final jet is coherent rather than a spray and thereby achieves a good cutting action.

Symmetrically disposed about the axis of the cutting head 1 are two inlets 11 and 12 for abrasive material, these inlets being connected via tubing 13 to a source 14 of suitable abrasive material such as wet or dry river sand. The inlets 11 and 12 are inclined relative to the axis of the body 2 so that their axes intersect with one another and with the central longitudinal axis of the cutting head at a point 15 upstream of the outlet 5 and that the projections of their cross-sections along their own axes fall on the wall 16, i.e. so that their axes intersect that part of the wall of mixing chamber 10 defined by the inner wall 16 of the insert 17; thus there is a straight line path from the inlets 11 and 12 to the zone within the wall 16. It will be seen that the lower edge of the side wall of each inlet 11, 12 is flush with the wall of mixing chamber 10.

It is believed that ideally the sand should be entrained in the jet as far downstream in the chamber 10 towards the outlet passage 18 as possible; this should minimise wear, particularly if the sand can travel in a straight line path from the inlet to its point of entrainment, while enabling the sand to be rapidly accelerated through the outlet 18. The disposition of the inlets 11 and 12 as just described is intended to ensure that entrainment occurs predominantly at the downstream end of the mixing chamber 10, this being within the wear resistant insert 17.

For optimum entrainment of the abrasive material

which is sucked into the mixing chamber 10, the axes of the inlets 11 and 12 should be inclined at as small an angle as possible to the axis of the body 2. Conveniently they are parallel to the side wall of the mixing chamber 10. In  
5 Figure 1, they are shown as each being at approximately 30° to the axis of body 2 and this has been found to produce satisfactory results. The inlets 11 and 12 are threaded so as to receive respective inlet pipes for the abrasive.

10 At its downstream end, the insert 17 has an annular shoulder 19 by means of which it is retained on the body 2 by a nut 20 which screw-fits to the body 2.

The left-hand side of Figure 2 shows that there may be a sudden change from the frusto-conical wall portion 16 to the cylindrical portion 18. However, as shown by the  
15 right-hand of Figure 2, it is preferred that these two portions merge progressively although this makes the insert more expensive.

In use, the cutting head 1 is directed towards the material 21 which is to be cut and the pump 7 is  
20 energised to deliver water at a suitable pressure. As the water issues from the insert 9, the abrasive material starts to be sucked from the inlets 11 and 12 and blasted towards the material 21 so that cutting takes place. The head may be guided by any suitable means to follow a  
25 desired cutting profile.

The position of the downstream end of the insert 9 is preferably chosen so that the stand-off distance from it to the material 21 being cut is an optimum and/or so that optimum entrainment of the abrasive material takes  
30 place. To enable this to be achieved, the insert 9 may, if desired, be screw-fitted to the body 2 so that its longitudinal position within the body may be adjusted as desired.

Where it is appropriate for the abrasive material in use, for example where it is a slurry such as wet sand, rather than relying on the suction of the jet, the abrasive

material may be pumped to the cutting head by a suitable pump.

5 As well as being used to cut shapes, the present cutting apparatus may also be used for drilling holes in material.

10 For enhanced performance, it may be desirable to extend the length of the outlet nozzle insert 17 so that the cylindrical passageway 18 is several inches long. The maximum desirable length of the insert 17 is about 18 inches.

15 Figures 4 and 5 show one version of a further embodiment of the present invention in which the sand is introduced into the mixing chamber 10 in such a way that it has a tangential component relative to the central axis X of the cutting head, and to enable this to be achieved the part of the mixing chamber defined by the body 2 should be frusto-conical. This is intended to impart a swirling motion to the sand and thereby enhance its entrainment by the water jet. The axes of the inlets still converge, as in the Figure 1 embodiment, but being in different planes, as viewed along the axis of the cutting head, they do not actually intersect with one another. In Figure 5, the line A-A indicates a plane containing the central axis X of the cutting head. The axis Y of one of the sand inlet passages 20 11 and 12 is contained in a plane B-B substantially parallel to the plane A-A. However, each sand inlet passage has its axis inclined so that, as in the embodiment of Figure 1, it is parallel with the frusto-conical inner wall of the insert 17, that is to say, the distance between the axis Y and a plane C-C, perpendicular to the plane A-A, decreases towards the outlet end of the cutting head, crossing this plane at a point within the frusto conical part of the outlet passage of the insert 17. As in Figure 30 1 the axes Y intersect with the inner wall 16 of the insert.

Figure 5 shows the case where there are two sand

inlet passages symmetrically disposed about the plane A-A. It will be appreciated that more than two symmetrically disposed sand inlet channels could be used, with these being directed so that they cause the sand to swirl in the same rotational direction.

In order to produce a cutting head which has a satisfactory cutting action at a reasonably economical cost and without excessive water and power consumption, the outlet aperture of the water nozzle 9 should preferably be from about 0.5 to 4 mm. The internal diameter of the outlet passage 18 of the outlet nozzle insert 17 should be somewhat greater than that of the water nozzle 9 preferably by about 0.5mm and is suitably between about 1 and 4 mm. The distance between the outlet end of the water nozzle and the outlet end of the insert 17 is preferably not more than about 250 mm.

Where, as in Figures 4 and 5 the axes of the sand inlet passages are offset from the central axis of the cutting head, this offset is preferably the same for each passage and between about 1 and 4 mm.

For optimum performance the ratio of the internal diameter of the water nozzle 9 to that of the passage 18 is preferably from 1:1 to 1:4 while the ratio of the distance between the outlet end of nozzle 9 and the outlet end of passage 18 and the length of passage 18 is preferably from 1:1.1 to 1:1.62.



CLAIMS

1. A high pressure liquid cutting head  
5 comprising a body having a through-passage having at its  
upstream end an inlet for liquid from a high pressure  
source, an outlet at its downstream end, a mixing zone  
intermediate the inlet and outlet ends, a nozzle  
arrangement for directing a jet of the liquid from the  
10 inlet through the mixing zone to the outlet and at least  
one inlet directed towards the outlet for introducing into  
the mixing zone abrasive material to be entrained by the  
jet of liquid, at least the downstream end of the mixing  
zone having a lateral wall which converges progressively  
15 towards the outlet.
2. A cutting head according to claim 1, wherein  
the internal diameter of the nozzle is between about 1 and  
about 4 mm.
- 20 3. A cutting head according to any one of the  
preceding claims wherein the ratio of the internal diameter  
of the outlet to that of the nozzle is from 1:1 to 1:4.
- 25 4. A cutting head according to any one of the  
preceding claims wherein the downstream end of the chamber,  
including at least the downstream part of the converging  
lateral wall, is defined by an annular insert of  
abrasive-resistant material.
- 30 5. A cutting head according to claim 4 wherein  
the axis of each inlet intersects said converging lateral  
wall within the insert.
6. A cutting head according to any one of the  
preceding claims wherein the projection of the cross  
section of each abrasive inlet along its own axis falls on

said converging lateral wall.

5        7. A cutting head according to any one of the  
preceding claims wherein there is a straight line path for  
abrasive material from the, or each, inlet and the  
downstream, converging portion of the mixing chamber.

10       8. A cutting head according to any one of the  
preceding claims wherein there is a plurality of abrasive  
material inlets and these are symmetrically disposed around  
the mixing zone.

15       9. A cutting head according to any one of the  
preceding claims wherein the stand-off of the nozzle  
arrangement from the mixing zone is adjustable.

20       10. A cutting head according to any one of the  
preceding claims wherein the axis of the, or each, abrasive  
inlet is contained in a plane offset from the axis of the  
mixing zone.

25       11. A high pressure liquid cutting apparatus  
incorporating a cutting head according to any one of the  
preceding claims.

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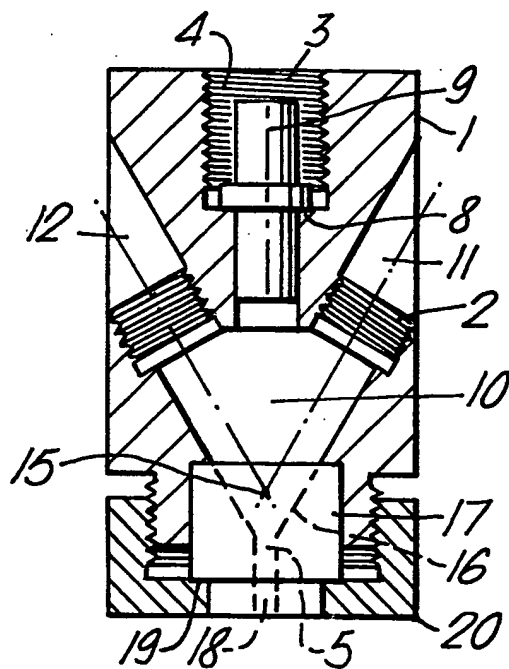


Fig. 1.

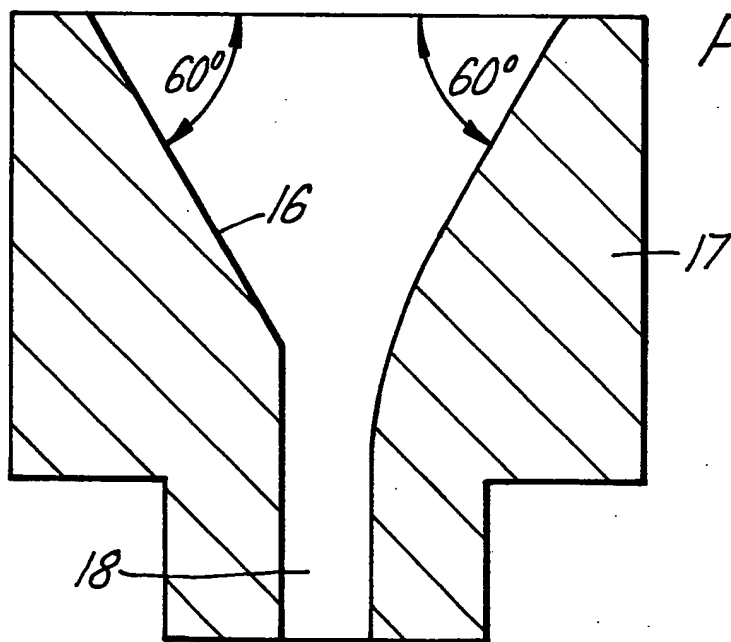
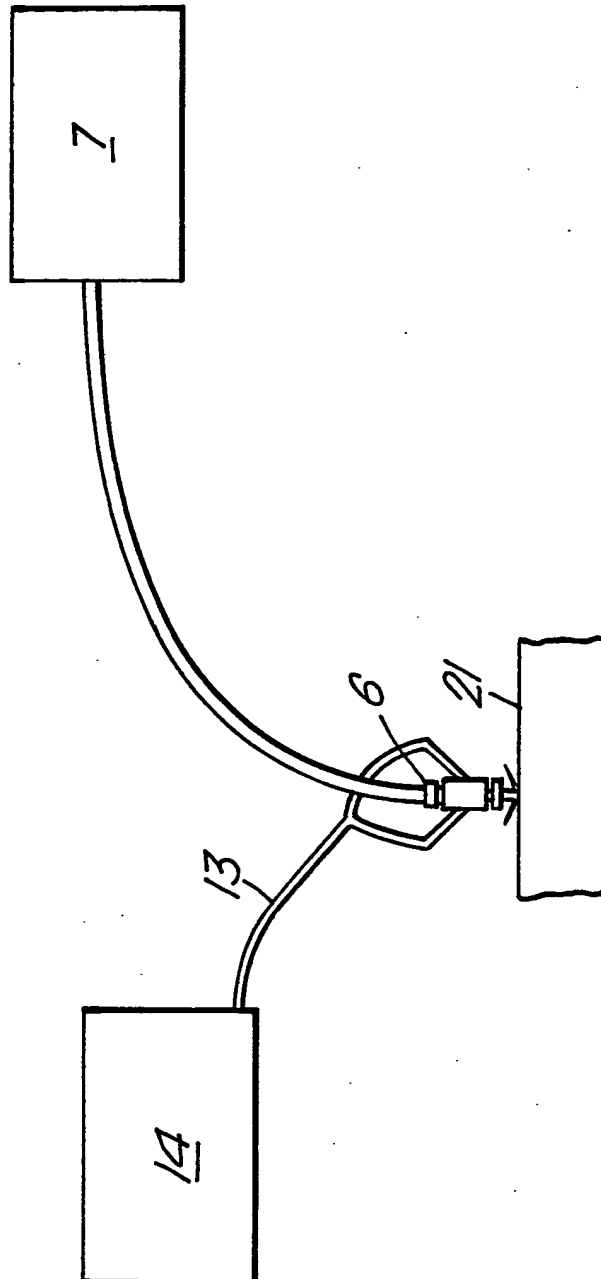


Fig. 2.

*Fig. 3.*

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Fig. 4.

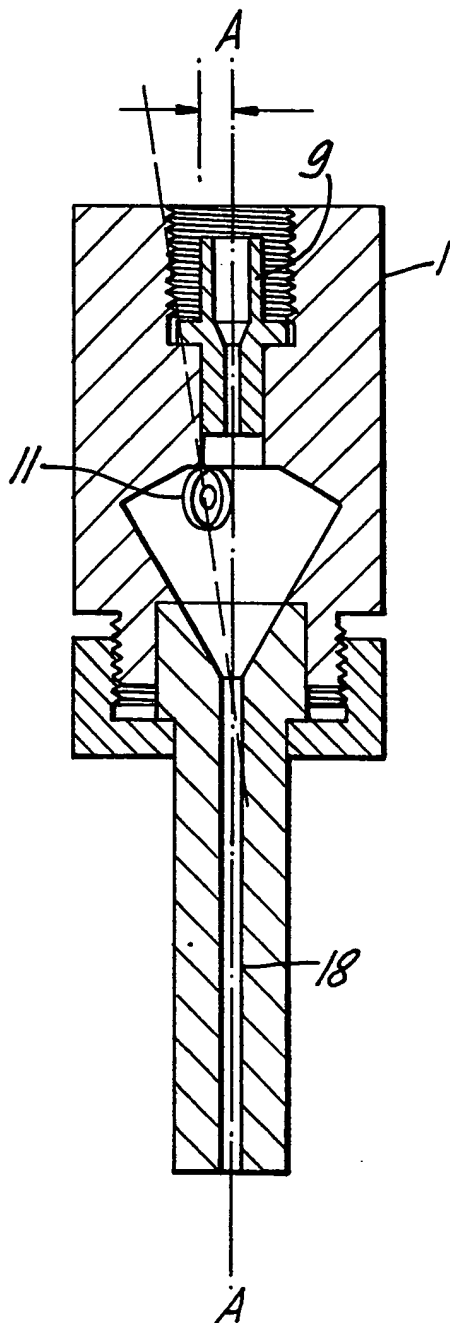
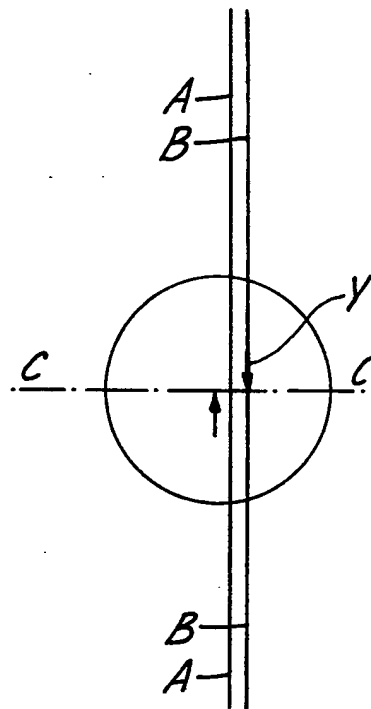


Fig. 5.





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>3</sup> )
X	DE-A-2 928 698 (RESEARCH DEVELOPMENT) * Claim 1; page 10, lines 6-13; page 11, line 15 - page 12, line 27; figure 1 *	1,3,4 8,11	B 26 F 3/00
A	--- CH-A- 567 907 (BENDIX) * Column 2, lines 64-66; figures 2,3 *	4	
A	--- DE-A-2 807 727 (PEININGER) * Figure 2 *	5-7	
A	--- FR-A-2 421 679 (LAMBERT) * Page 4, lines 33-35 *	9	
A	--- GB-A-1 183 342 (ROTO-FINISH) * Page 1, lines 68-74; figure 2 *	10	TECHNICAL FIELDS SEARCHED (Int. Cl. <sup>3</sup> )  B 26 F B 24 C B 05 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 26-10-1983	Examiner COLAS R.P.
<b>CATEGORY OF CITED DOCUMENTS</b>  X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document  T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons  & : member of the same patent family, corresponding document			